

# Smart Universal Power Electronic Regulators (SUPERs) & Intelligent Power Stages (IPSSs)

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**Project Status:** Ended **Project Term:** 8/25/2020 – 12/31/2022 **Award Amount:** \$390,485 **Partners:** ORNL

## Project Summary

The project focuses on developing and validating an intelligent power stage (IPS) incorporating system interoperability, diagnostics, and prognostics features.

## Technical Approach

Design a base 75 kW, 1000 V<sub>DC</sub> to 480 V<sub>AC</sub> inverter platform and add voltage and current sensors to the SiC devices and then utilize the measurements in both hardware and software to implement shoot through protection and on state resistance measurement. The telemetry collected from the sensors can then be sent to the Smart Universal Power Electronic Regulator (SUPER) via a fiberoptic interconnect and processed to analyze device aging and lifetime estimation.

## Accomplishments

- Development of an interoperable inverter with a secondary controller (IPS-SUPER)
  - Operation of the IPS with an emulated SUPER with less than 1 switching cycle delay at 30 kHz switching
  - Operation of communication channels for controls and telemetry without data
  - Operation at 75 kW with up to 98.36 % efficiency
- Development of key elements/sensors/modules to monitor and report on status of the IPS (Diagnostics and Prognostics)
  - Key feature for diagnostics: Shoot-through detection of SiC power modules with ~521ns for protection
  - Key features for prognostics:
    - Resistance change and characterization of SiC semiconductor power modules.
    - DC-link capacitor health monitoring
    - Resistance measurement is both online and in-situ

## Impact/Commercialization

Two patent applications were filed using the knowledge gained in this project. These pending patents have been licensed to PowerSensAI Inc. Engineering samples of the V-on sensor are now available on Digikey.



## IP STATUS

Patent applications:

- Title: On-State Voltage Measurement of High-Side Power Transistors in Three-Phase Four-Leg Inverter for In-Situ Prognostics  
No.: 17/870,512 Inventor(s): Chondon Roy, Namwon Kim, James Gafford, and Babak Parkhideh
- Title: Switch Current Sensor  
No.: PCT/US23/013253 Inventor(s): Ali Parsa-Sirat, Hossein Niakan, and Babak Parkhideh

## Future Work

- Extending the range of Von/Ron measurements
- Improving the accuracy of measurements in both directions.
- Inferencing of measured data at SUPER; Digital Twin development of the IPSSs

